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TRANSMITTAL OF ENGLISH TRANSLATION

Dear Sir:

Referencing the Information Disclosure Statement dated March 8, 2001 in the above-identified application, an English translation of Japanese document no. 07-007060, listed on form PTO-1449 at Item AN is filed herewith.

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Respectfully submitted,

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(54) [Title of the Device] ION BEAM EXTRACTION ELECTRODE SYSTEM DEVICE

[Abstract]

[Purpose] To separate a dopant ion and a balance gas ion only by a magnetic field.

[Constitution] A dopant ion M and a balance gas ion m are extracted from a source plasma by a plasma electrode 1 and an extraction electrode 2. A magnetic field B is formed between the extraction electrode and an electron suppression electrode 5 by a permanent magnet 17. The ion performs Larmor precession in the magnetic field to be bent. The dopant ion and the balance gas ion are different in bending way due to a difference in mass. The axis x of beam extraction holes 7 of the plasma electrode and the extraction electrode in the upstream of a beam from the magnetic field is shifted from the axis x' of beam extraction holes of the electron suppression electrode 5 and a grounding electrode 6 in the downstream. The balance gas ion collides with the electron suppression electrode or the grounding electrode to be cut, so that only the dopant ion is extracted.

[Claims]

[Claim 1] An ion beam extraction electrode system device, in a large-area ion implantation apparatus taking mixed plasma of a dopant ion and a balance gas ion as a source plasma, characterized in that a magnetic field is formed between an extraction electrode and an electron suppression electrode.

[Claim 2] The ion beam extraction electrode system device according to claim 1, wherein the electrode in the upstream of a beam from the magnetic field and the electrode in the downstream of the beam are disposed so that the axes of beam extraction holes formed therein are shifted from each other.

[Brief Description of the Drawings]

[Fig. 1] A sectional view of an embodiment according to the invention.

[Fig. 2] A sectional view of an ion beam extraction electrode system incorporating a mass separation electrode constituting the previously proposed E x B filter.

[Fig. 3] A front view of a mass separation electrode seen from the upstream side of the beam.

[Description of the Reference Numerals and Signs]

1 plasma electrode

2 extraction electrode

5 electron suppression electrode

6 grounding electrode

7 beam extraction hole

17 permanent magnet

[Detailed Description of the Invention]

[0001]

[Industrial Field of Application]

This invention relates to an ion beam extraction electrode system device capable of separating a dopant ion and a balance gas ion without a mass separation electrode constituting an E x B filter.

[0002]

[Prior Art]

In ion implantation for a semiconductor device serving as a driving circuit of a liquid crystal device by a thin film transistor, polycrystalline silicone and amorphous silicon, a plane ion beam having a large sectional area is used. In this type of a large area ion implantation apparatus, however, mass separation means formed by an E x B (E cross B) filter (another name is Vienna filter) is used for ions extracted to an ion source to thereby implant only necessary ions, so that the implantation quality has been developed.

[0003]

Fig. 2 relates to a beam extraction electrode system in this type of the large area ion implantation apparatus and it is a block diagram showing the section of a plane ion beam extraction electrode system incorporating a mass separation electrode constituting an E x B filter proposed by the inventor of the present invention. Fig. 3 is a sectional view of a mass separation electrode seen from the upstream side of a beam. As shown

in Fig. 2, the plane ion beam extraction electrode system has a plasma electrode 1 and an extraction electrode 2 in order from the high frequency ion source side, for example, and a mass separation electrode 3 is disposed between the extraction electrode and a suppression electrode (similarly called extraction electrode) 4. In the extraction electrode system, further an electron suppression electrode (decelerating electrode) 5 and a grounding electrode 6 are provided in the downstream of the suppression electrode 4.

[0004]

The respective electrodes except the mass separation electrode 3 are porous electrodes having a number of beam extraction holes 7, and the mass separation electrode is provided with a number of beam extraction space parts 8 for mass separation formed corresponding to the positions of the beam extraction holes. An extraction power supply 9, an accelerating power supply 10 and a decelerating power supply 11 are connected with the illustrated polarity to the respective electrodes of the beam extraction electrode system to thereby extract and accelerate ion beams from the ion source.

[0005]

The mass separation electrode 3 has a plurality of non-magnetic holders 12 arranged in parallel at a space. The respective holders are provided with magnet arrangement holes 13 formed at spaces, and a filter magnetic field forming permanent magnet 14 is accommodated and fixed in each of the holes.

[0006]

In each holder 12, an elongated hole 15 is bored intersecting perpendicularly to the magnet arrangement hole 13 for accommodating a permanent magnet between the fixed positions of the permanent magnets 14. Two sheets of electrode elements 16_1, 16_2 for forming a filter electric field insulated from each other are inserted and disposed in the elongated holes 15 of the plurality of holders 12. Accordingly, the space between the holders in which the permanent magnets 14 fixed to the respective holders 12 are opposite to each other is partitioned by the electrode elements 16_1, 16_2 for forming a filter electric field to thereby form a beam extraction space part 8 of the E x B filter for

mass separation.

[0007]

The permanent magnet 14 is magnetized to be of illustrated polarity, and two sheets of electrode elements 16_1, 16_2 inserted in the elongated holes 15 of the holders 12 are given a potential difference by a filter power supply 17. With this operation, a filter magnetic field and an electric field intersecting perpendicularly to each other are formed in each beam extraction space part 8 by two opposite permanent magnets 14 and the electrode elements 16_1 and 16_2 facing on the above space part and given a potential difference, so that only the ions having a balance between the force applied by the electric field and the force applied by the magnetic field pass through the space part to accomplish required ion mass separation.

[0008]

[Problems that the Invention is to Solve]

In the large area ion implantation apparatus, in the case of implanting dopant such as boron and phosphorus in a body to be implanted, as a specified substance source gas in an ion source, used is hydride gas obtained by mixing and diluting material gas such as diborane or silane with balance gas such as hydrogen or helium, and mixed plasma of a dopant ion and a balance gas ion is generated in the ion source. When ions are extracted from the ion source taking the above mixed plasma as the source plasma, a balance gas ion is also extracted with an aimed dopant ion. In the above beam extraction electrode system, a number of mass separation electrodes 3 constituting an E x B filter are incorporated, whereby a balance gas ion is removed, and a beam of an aimed dopant ion only can be extracted.

[0009]

It is, however, necessary for the mass separation electrodes 3 constituting the E x B filter to form a number of E x B filter units extending over a large area corresponding to the positions of the beam extraction holes 7 of the respective electrodes. Therefore, the mass separation electrodes 3 are required to have a complicated and precise structure,

so in manufacture, high technology and a huge cost are needed.

[0010]

It is an object of the invention to provide an ion beam extraction electrode system device having a mass separation mechanism for ions using Larmor precession of the ion in a magnetic field, not using an E x B filter system.

[0011]

[Means for Solving the Problems]

According to the invention, an ion beam extraction electrode system device of a large area ion implantation apparatus taking mixed plasma of a dopant ion and a balance gas ion as a source plasma is mainly characterized in that a magnetic field is formed between an extraction electrode and an electron suppression electrode.

[0012]

Further, according to the invention, the ion beam extraction electrode system device is characterized in that an electrode in the upstream of a beam from the magnetic field and an electrode in the downstream of the beam are disposed so that the axes of the beam extraction holes formed in the electrodes are shifted from each other.

[0013]

[Operation]

The ion which has passed through the extraction electrode is caused to perform Larmor precession by the magnetic field, so that an ion beam is bent. As for the bending way, a small-mass balance gas ion is large, and a dopant ion having a larger mass than the ion is small, so both ions can be separated.

[0014]

Since the ion beam is bent by the magnetic field, and the dopant ion and the balance gas ion are different in bending way, the axes of the beam extraction holes of the electrode in the upstream of the beam from the magnetic field and the electrode in the downstream of the beam are shifted from each other to cut the balance gas ion by the electrode in the downstream of the beam, so that only the beam of the dopant ion can be

extracted.

[0015]

[Embodiment]

An embodiment of the invention will now be described with reference to the attached drawings. Fig. 1 is a sectional view of a beam extraction electrode system, and the same reference numerals as those of Figs. 2 and 3 designate the same or equivalent parts. An ion beam is extracted from a source plasma of an ion source by a plasma electrode 1 and an extraction electrode 2. In a space part where the beam passes between the extraction electrode 2 and the electron suppression electrode 5, as indicated by dotted line frames, permanent magnets 17 are disposed opposite to each other, thereby forming a magnetic field B in the vertical direction to the paper plane.

[0016]

The ion beam which has passed through the beam extraction hole 7 of the extraction electrode 2 to be introduced into a magnetic field region receives the force applied by the magnetic field B. The ion performs circular motion having a Larmor radius proportional to its mass and Larmor precession. As already mentioned, in the large area ion implantation apparatus, material gas for making a dopant ion and balance gas such as hydrogen or helium are mixed to generate a source plasma. In this case, however, the mass ratio of the necessary dopant ion M to the unnecessary balance gas ion m extracted from the plasma is large so that the ratio of Larmor radius becomes larger.

[0017]

The respective electrodes are configured so that the axis x of each beam extraction hole 7 of the plasma electrode 1 and the extraction electrode 2 is a little shifted from the axis x' of each beam extraction hole 7 of an electron suppression electrode 5 and a grounding electrode 6. Thus, the beam upstream electrode from the magnetic field and the beam downstream electrode are disposed with the axes x, x' of the beam extraction holes 7 shifted from each other, whereby between the dopant ion M and the balance gas ion m advancing along different trajectories by Larmor precession, only the

dopant ion M finally passes through the beam extraction hole 7 of the grounding electrode 6 to be extracted, and the balance gas ion having a smaller Larmor radius collides with the electron suppression electrode 5 or the grounding electrode 6 to be cut.

[0018]

In the above embodiment, the magnetic field is formed between the extraction electrode 2 and the electron suppression electrode 6, and the suppression electrode 4 in the electrode system shown in Fig. 2 is not provided. In the case of the beam extraction electrode system incorporating the mass separation electrode 3 constituting the E x B filter shown in Figs. 2 and 3, since the dopant ion is moved rectilinearly by the E x B filter, and only the balance gas ion is deflected to perform mass separation, the electrode parts are configured so that the mass separation electrode is clamped by the extraction electrode 2 and the suppression electrode 3 biased at the same potential not to apply an electric field except the filter electric field to the E x B filter part of the mass separation electrode. On this point, in the case of performing mass separation by Larmor precession of the ion, although the dopant ion and the balance gas ion are different in Larmor radius, both ions perform Larmor precession, and the beams are bent, so that these ions pass through the extraction electrode 2 to be throttled toward the electron suppression electrode 6 having negative higher potential than the electrode, thereby forming a magnetic field in an accelerated area.

[0019]

[Advantage of the Invention]

According to the invention, as described above, the ions extracted from the mixed source plasma of a dopant ion and balance gas ion are caused to perform circular motion having a Larmor radius proportional to its mass and Larmor precession by the magnetic field, whereby the dopant ion and the balance gas ion can be separated due to a difference in mass without the E x B filter in a simple structure using the magnetic field only, and furthermore, the suppression electrode is dispensable so as to further simplify the beam extraction electrode system.

[0020]

Although the ion beam is bent by the magnetic field, the dopant ion and the balance gas ion are different in bending way. Accordingly, the axes of the beam extraction holes of the electrode in the upstream of the beam from the magnetic field and the electrode in the downstream of the beam are shifted from each other, whereby the balance gas ion is cut by the electrode in the downstream of the beam, and only the beam of the dopant ion can be extracted.

FIGURE 1:

SOURCE PLASMA

FIGURE 2:

SOURCE PLASMA